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DP-301500/301244A

A GAS SENSOR TERMINAL ASSEMBLY AND METHOD OF PRODUCING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This case claims the benefit of the filing date of the provisional application, U.S. Provisional Application Serial No. 60/161,839, filed October 27, 1999 that is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

This invention relates to gas sensors, and, more particularly, to gas sensor terminal assembly.

BACKGROUND OF THE INVENTION

Oxygen sensors are used in a variety of applications that require qualitative and quantitative analysis of gases. In automotive applications, the direct relationship between the oxygen concentration in the exhaust gas and the air-to-fuel ratio of the fuel mixture supplied to the engine allows the oxygen sensor to provide oxygen concentration measurements for determination of optimum combustion conditions, maximization of fuel economy, and the management of exhaust emissions.

A conventional stoichiometric oxygen sensor typically comprises an ionically conductive solid electrolyte material, a porous electrode on the exterior surface of the electrolyte exposed to the exhaust gases with a porous protective overcoat, and an electrode on the interior surface of the sensor exposed to a known oxygen partial pressure. Sensors typically used in automotive applications use a yttria stabilized zirconia based electrochemical galvanic cell with platinum electrodes, which operate in potentiometric mode to detect the relative amounts of oxygen present in the exhaust of an automobile engine. When opposite surfaces of this galvanic cell are exposed to different oxygen partial pressures, an

electromotive force is developed between the electrodes on the opposite surfaces of the zirconia wall, according to the Nernst equation:

$$E = \left(\frac{RT}{4F}\right)\ln\left(\frac{P_{O_2}^{ref}}{P_{O_2}}\right)$$

where:

E	=	electromotive force
R	=	universal gas constant
F	=	Faraday constant
T	=	absolute temperature of the gas
$P_{O_2}^{ref}$	=	oxygen partial pressure of the reference gas
P_{O_2}	=	oxygen partial pressure of the exhaust gas

Due to the large difference in oxygen partial pressure between fuel rich and fuel lean exhaust conditions, the electromotive force (emf) changes sharply at the stoichiometric point, giving rise to the characteristic switching behavior of these sensors. Consequently, these potentiometric oxygen sensors indicate qualitatively whether the engine is operating fuel-rich or fuel-lean, conditions without quantifying the actual air-to-fuel ratio of the exhaust mixture.

Sensors are electrically connected to the vehicle electrical system through the sensor body and wiring harness. Within the sensor is an element used for sensing exhaust gases. Contact pads are disposed on the exterior of the sensing element to provide for electrical communication between the sensing element and the vehicle electrical system. Edge card connectors or terminals are generally used to make contact with the sensing element via the contact pads. As illustrated in prior art Figure 1, a typical sensor 100 utilizes a spring clip 101 to hold an adaptor 104 comprising male 102 and female 103 terminals within the sensor 100. A glass support 105 and a wedge ring 106 is disposed between the upper insulator 107 and a glass seal 108. A protective shield 109 surrounds the lower portion of the wiring harness assembly. In conventional designs, the terminals also support the weight of the sensing element and position the sensing element within the sensor, as illustrated in prior art Figure 1. At the same time, the weight from the internal components of the wiring harness is also transferred to the terminals. Typically, the sensing element and terminals have problems with handling the weight of the wiring harness and the sensing element, as well as maintaining the position of the

sensing element within the sensor. The fragile elements have a tendency to break under the weight of the terminals and by movement within the sensor during the manufacture, testing, and operation of these conventional sensors.

What is needed in the art is a terminal connector that supports and aligns the sensing element within the sensor, while minimizing stress to the sensing element.

BRIEF SUMMARY OF THE INVENTION

The deficiencies of the above-discussed prior art are overcome or alleviated by a terminal connector assembly, gas sensor, and method of producing a gas sensor.

The terminal connector assembly comprises: a terminal support, a terminal disposed at least partially within the terminal support, and a first insulator having a passage with an indentation adjacent to the terminal and the terminal support.

The gas sensor comprises: a sensing element, having a lower portion disposed within a subassembly and an upper portion disposed within a wiring harness assembly comprising an upper shield disposed around a wiring harness. A terminal support is disposed within the wiring harness. A first portion of a terminal is disposed within the terminal support and in electrical communication with the sensing element. A first insulator is at least partially disposed within the upper shield and around the sensing element upper portion. The first insulator has a passage for receiving a second portion of the terminal, such that at least a portion of the first insulator is disposed between the terminal, the second portion and the upper shield.

A method of producing a gas sensor comprises disposing an upper portion of a sensing element within a wiring harness assembly comprising an upper shield disposed around a wiring harness. Disposing a lower portion of the sensing element within a subassembly and disposing a terminal support within the wiring harness. Also disposing a first portion of a terminal within the terminal support and in electrical communication with the sensing element. Disposing a first insulator at least partially within the upper shield and around the sensing element

upper portion. The first insulator has a passage for receiving a second portion of the terminal, such that at least a portion of the first insulator is disposed between the terminal, the second portion and the upper shield. Exposing the sensor to engine operating conditions.

The above-described and other features and advantages of the present invention will be appreciated and understood by those skilled in the art from the following detailed description, drawings, and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The apparatus and method will now be described by way of example, with reference to the accompanying drawing, which is meant to be exemplary, not limiting.

Figure 1 is a cross-sectional view of a prior art gas sensor design.

Figure 2 is a cross-sectional view of one embodiment of a gas sensor design.

Figure 3 is a side view of exemplary terminals, cables, and a sensing element.

Figure 4 is an isometric side view of an exemplary terminal support.

Figure 5 is an isometric bottom view of an exemplary terminal support.

Figure 6 is a cross-sectional view of an exemplary terminal support, taken along lines 6-6 of Figure 4.

DETAILED DESCRIPTION OF THE INVENTION

Sensors are used in automobile engines to monitor the exhaust for the presence of different gases. The sensor typically comprises: a wiring harness having an upper shield, a seal, electrical components, and the upper portion of a sensing element; and a subassembly having a shell, a lower shield, an internal shield, a high temperature material, and the lower portion of a sensing element. The sensing element within the sensor is a fragile device that should be maintained in position to prevent breakage. Conventional sensors are designed such that the weight of the wiring harness is distributed to the sensing element. In contrast to

conventional sensors, the terminals, terminal support and first insulator herein support and protect the sensing element from movement within the sensor, as well as helping to support the weight of the wiring harness.

Referring now to Figure 2, the exemplary oxygen sensor 10, having a wiring harness assembly 12 and a subassembly 14, is illustrated. The wiring harness assembly 12 generally includes the seal 40 and electrical components connected to the upper portion 84 of the sensing element 80 within the upper shield 20. The subassembly 14 generally includes the lower portion of the sensing element 80, an internal shield 35 in a lower shield 30, and a shell 50. Exemplary materials for the shields 20, 30, and 35 and for the shell 50 are stainless steels such as high chrome and/or high nickel stainless steels, and mixtures and alloys comprising at least one of the foregoing stainless steels, and the like, with all materials chosen for high temperature endurance, high-strength and corrosion resistance.

The fastener or seal 40 disposed within a portion of the upper end 22 of the upper shield 20, can comprise material capable of withstanding temperatures commensurate with the operation of an engine (e.g., temperatures up to about 1,000°C, with the sensor experiencing temperatures up to about 300°C). Typical materials include fluoroelastomer, silicone, rubber, perfluoroelastomer, as well as other conventional seal materials, and combinations comprising at least one of the foregoing materials. The seal can be made by conventional molding techniques known in the art.

One possible seal is disclosed in Patent Application _______, Attorney Docket No. DP-301500/DP-301244B (DEP-0133F) that is incorporated herein by reference in its entirety. This one-piece, multi-functional seal 40 provides dampening, structural integrity, and protects the sensing element 80 by preventing the intrusion of water or other contaminants from entering the sensor 10. The seal 40 can be designed to fit into the upper portion 22 of the upper shield 20 for a secure fit. The seal's optional flange provides additional sealing between the seal 40 and the upper shield 20. Once the upper shield 20 is under the flange, the seal 40 can be crimped in place by crimping operations known in the art, which distort or form the seal 40 to the shape of the upper shield 20, creating a seal 40

that closes off contaminants from entering the sensor. Additionally, during use, namely exposure to high temperatures, the flange of the seal 40 shrinks into the upper shield 20, thus providing added protection for the sensor 10 against exposure to contaminants.

As stated above, the seal 40 can act as a dampening device against any vibration or shock loads. The optional projections on the bottom of the lower portion of the seal 40 are designed to contact with the terminal support 60 and to dampen vibrations or shock loads that impact the sensor 10. The projections act similar to a spring, absorbing the vibrations while minimizing contact to the terminal support 60. Since, the seal 40 only physically contacts the terminal support 60 at the projections, an air gap is formed therebetween. This air gap insulates the seal 40, minimizing the convective transfer of heat from the lower sensor components to the seal 40.

To provide for electrical connection of the sensor 10, a terminal support 60 is disposed adjacent to the seal 40. The terminal support 60 may be formed of a material that is durable under sensor operation conditions. These materials, which should be chosen to provide for electrical insulation, thermal resistance, and mechanical support, can include thermoplastic; thermoset; ceramic, such as steatite, alumina, and the like; among others, and combinations comprising at least one of the foregoing terminal support materials, with ceramics and plastics often employed.

The terminal support 60 holds into place an edge card connector, terminal connector, or terminal(s) 62, 63 that are connected to cable(s) or wire(s) 64, 65. The cables 64, 65 connect the vehicle electrical system to the wiring harness 12. The cables 64, 65 can be comprised of materials that are generally those that are known in the art, including copper, brass, stainless steel, nickel, and the like, as well as combinations and alloys comprising at least one of the foregoing materials. The terminals 62, 63 are generally comprised of materials known in the art, which may include stainless steel, copper, brass, nickel, and the like, as well as combinations and alloys comprising at least one of the foregoing materials. Materials, and a terminal design, which provide a substantial spring force under sensor operating conditions is preferred.

The terminals 62, 63 are in electrical communication with the contact pads 86, 88 of the sensing element 80. Portions of the sensing element 80 are disposed within the upper shield 20, the shell 50 and the lower shield 30. The sensing element 80 can be a planar or flat plate sensing element of a known type. At a first end 82 thereof, disposed in lower shield 30, the sensing element 80 includes an exhaust constituent-responsive structure fabricated into the sensing element in a known manner, preferably along with a heater of a known type. Disposed at or near the second end of the sensing element 80 are contact pads 86, 88, that are comprised of conventional materials known in the art.

In addition to electrically connecting to contact pads 86, 88, terminals 62, 63 preferably physically contact the first insulator 90. This first insulator 90 is disposed within at least a portion of both the upper shield 20 and the shell 50. The first insulator 90 comprises a high temperature material (i.e., a material capable of withstanding the sensor operation conditions), to provide insulation for the sensor 10. Some possible high temperature materials which are chosen for electrical insulation, thermal resistance, and mechanical support, include ceramics and metals, among others, and combinations, alloys, and composites comprising at least one of the foregoing materials in the form of fibers (random, chopped, continuous, woven, and the like), woven and non-woven mesh, among others. The ceramic can include steatite, alumina, or the like, or combinations comprising at least one of the foregoing ceramics. Optionally, the first insulator 90 can comprise a ceramic upper portion comprising the shelf 94 and a metal mesh lower portion disposed through at least a portion of the shell 50. The first insulator 90 can be a cylindrical device with a passage 93 of various widths for the insertion of the terminals 62, 63 and the sensing element 80. The terminals 62, 63 are positioned such that the weight of the terminals 62, 63 is supported by the first insulator 90.

The first insulator 90 optionally comprises an indentation or shelf 94 that extends outward from the passage 93 within the interior of the upper portion 91 of the first insulator 90. The shelf 94 preferably extends into the first insulator 90 at a distance sufficient to receive terminals 62, 63, such that the terminals 62, 63 fit into, rest on, or are supported by an indentation or support shelf

94 near the top of the first insulator 90. Preferably, the shelf 94 preferably has a width substantially similar distance from an outside of one terminal to the outside of an opposite terminal. The first insulator 90 surrounds the sensing element 80 while providing support to and positioning the sensing element 80 within the sensor 10. By supporting the weight of the terminals 62, 63 and the terminal support 60, the first insulator 90 removes the weight and force from damaging the sensing element 80. The first insulator 90 can be connected to the sensor 10 through a crimping method, or other method known in the art.

The lower portion of the first insulator 90 is disposed within the shell 50. The shell 50 has a body portion 52 and a threaded portion 54. The body portion 52 is preferably shaped to accommodate a wrench or other tool for tightening the threaded portion 54 into a mount for an exhaust pipe or other component of an exhaust flow system, or wherever the gas sensor will be employed, thus, enabling a sensor chamber 31, to be located within a flow of gasses to be measured. The shell 50 can be coupled to the upper shield 20 by a crimping or other process known in the art.

Optionally disposed on a lower portion of the shell 50 is a gasket 72, which provides a source of tension to help retain sensor 10 in operational position and seal the sensor and manifold from gas leakage. Another optional item that can be disposed within the shell 50 adjacent to the sensing element 80 and between the first insulator 90 and the second insulator 92 is a talc pack 70 or other structural or sealing component. The talc pack 70 can be disposed between the first insulator 90 and the second insulator 92, or between the shell shoulder 56 and the insulator 90, 92 or mesh. The talc pack 70 holds the sensing element in place by compacting talc powder around it. Alternatively, the talc pack 70 serves as a leak resistant seal that can be obtained by employing an inorganic material such as talc, mica, kaolin, and the like, as well as combinations comprising at least one of the foregoing inorganic materials, between the sensing element 80 and lower shield 30.

Disposed within the shell 50 and adjacent to the talc pack 70 can be the second insulator 92. The second insulator 92 is comprised of the same or

similar high temperature material as the first insulator 90 and insulates and protects the sensor 10.

Adjacent to the second insulator 92 can be the sensing chamber 31. The lower shield 30 is securely coupled to the shell 50 such that a first end 82 of the sensing element 80 is disposed within the sensing chamber 31 to permit contact with and sensing of gas. The lower shield 30 defines the sensing chamber 31 and, disposed within the lower shield 30, is an internal shield 35 for receiving the sensing element 80. The lower shield 30 and the internal shield 35 incorporate a plurality of apertures 38, 39 for allowing passage of exhaust gas in and out of the sensing chamber 31 so that the gasses may be sensed by the receptive first end 82 of the sensing element 80.

To operate the sensor 10, an electrical connection needs to be secured between the sensing element 80 and the wiring harness 12 that connects to the vehicle electrical system. As shown in Figure 3, the terminals 62, 63 connect with the contact pads 68, 69 located on the sensing element 80 placing the terminals 62, 63 and sensing element 80 in electrical communication. The terminals 62, 63 can hold or retain the sensing element 80 in place by utilizing a spring design, as is known in the art. The extended piece 66, 67 of each terminal is depressed against the contacts 68, 69 of the element creating a spring-like effect. This keeps the element 80 under tension between the terminals 62, 63 and retains the electrical connection, as well as the position of the element 80 in the sensor 10. As illustrated in Figure 2, the terminals 62, 63 are held in place within the wiring harness 12 by two separate elements: a terminal support 60 and an first insulator 90. The terminals 62, 63 are allowed to flex and distribute vibration and shock loads to the terminal support 60 and the first insulator 90, thus protecting the sensing element 80.

Referring now to Figure 4, the terminal support or lock, shown generally at 60, is illustrated. The terminal support 60 is illustrated having a generally cylindrical shape with at least one flat side 120, however, other designs are possible such as multi-sided, and the like. Located within the top 122 of the terminal support 60 are channels or holes 130 for receiving terminals (not shown) and electrical cables (not shown). Referring now to Figure 5, the bottom 124 of

the terminal support 60 with at least one flat side 120 is illustrated. The figure illustrates the reverse side (the bottom 124) of the channels 130 that extend through the terminal support 60. Within the channels 130, an indentation or pocket 132 is created within each channel 130 for receiving and supporting the terminals (not shown).

Referring now to Figure 6, a cross-section of the terminal support 60 is illustrated. The channels 130 open through the top 120 and extend out through the bottom 124 of the terminal support 60. The indentations 132 located within the channels 130 create a larger space for receiving the terminals (not shown). The terminal support 60 isolates the terminals 62, 63 from each other and holds the terminals 62, 63 in position at the top of the sensing element 80. Consequently, the terminal support should be dielectric material having a sufficient number of channels 130 to receive the desired number of wires (not shown) and terminals. The particular spacing and orientation of the channels 130 is chosen based upon the desired number of cables and terminals, and manufacturing capabilities.

Because of the combination of the terminal support, first insulator and terminals, the sensing element will be protected from exposure to the weight of the terminals, movement within the sensor, as well as the effects of vibrations. As a result, the sensor life is extended. For example, while conventional sensors typically degrade, the present sensor can withstand vibration testing (e.g., 90 hours at about 950°C and 200 - 400 hertz, with an acceleration of 22G). In another test where many conventional sensors failed in about 100 hours (e.g., the sensor element breaks and/or the terminal connectors move creating unacceptable resistance), the present sensor withstood 2,000 hours of durability testing on an engine dynamometer (equivalent to about 150,000 miles on a car). Other tests which were successfully passed include a weight drop test (1 kilogram (kg) weight was dropped on the shell (commonly known as the "hex") at varying heights) and a ball drop test (100 gram ball was dropped from 1 meter onto the sensor at 4 different points). With the weight drop test the present sensor withstood drops from about 3 times as high as a conventional sensor (e.g., about 45 cm versus 15 cm for a conventional sensor). Additionally, with the ball drop test, the sensor

passed the test while conventional sensors failed. An additional benefit of this sensor design is that the terminal support system is easy to install and cost effective.

While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention, including the use of the geometries taught herein in other conventional sensors. Accordingly, it is to be understood that the apparatus and method have been described by way of illustration only, and such illustrations and embodiments as have been disclosed herein are not to be construed as limiting to the claims.

We claim: